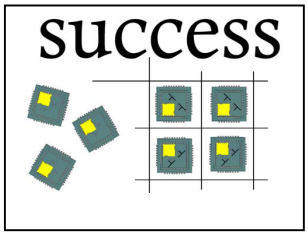
Towards Miniaturized Low-Cost mm-Wave Communications and Sensor Systems

SUCCESS is an initiative of 9 industrial and academic organisations. Goals are to develop design & test methodologies for highly-integrated mm-wave sensors based on silicon semiconductor technology and novel low-cost mm-wave packaging. The methodologies are demonstrated by means of a 122 GHz Radar System-In-Package.

At A Glance:

Silicon-based Ultra-Compact Cost-Efficient Sensor System Design



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Duration: Dec. 2010 to Nov. 2013

Funding scheme: STREP

Total Cost: € 4.813 Mio..

EC Contribution: € 2.989 Mio.

Contract Number: INFSO-ICT-248120

Main Objectives

SUCCESS targets to develop a technology platform and best-practice design methods to enable a cost breakthrough of silicon mm-Wave System-On-Chips (SoCs) for high-volume applications.

Three topics will be addressed in the project:

1. Development of a **low-cost System-In-Package (SiP)** technology platform with integrated antennas based on SMD-type plastic package.

2. **mm-Wave System-on-Chip (SoC)** design methodology

3. **mm-Wave Built-In Self Test (BIST)** and novel **SiP test** methodology

The results will be demonstrated in a **122 GHz miniaturized RADAR sensor system**, realized as an SMD plastic packaged component.

SUCCESS targets the commercial breakthrough of silicon semiconductor technologies for high-volume mm-wave applications

The project brings together partners from **Germany, France, Switzerland, Finland, Poland, and Canada**. Its consortium encompasses **6 industry partners:** Bosch, STMicro, Hitech, Selmic, Evatronix, and Silicon Radar, as well as **3 academic partners:** IHP, Karlsruhe Institute of Technology , and University of Toronto.

Europe plays a leading role in providing mm-wave SiGe BiCMOS technologies (STMicro, Infineon, IHP), mm-wave CMOS technologies (STMicro). However broad commercial success of mm-wave semiconductor technologies and mm-wave wireless applications is heavily handicapped by cost of conventional high-frequency package and antenna technology, complicated mm-wave IC design, and basically unavailable mm-wave production test methodologies rsp. equipment.

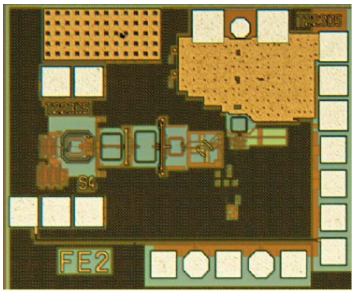

Fig. 1 122 GHz Receiver in IHP's 0.25 µm SiGe technology

SUCCESS aims to solve these problems by developing cost-efficient solutions for mm-wave SiP chip and antenna integration, mm-Wave SoC design methodology, and mm-wave BIST. Research on European scale enables to bring together partners and know-how from every aspect of the microelectronics food chain such as semiconductor foundries, digital and RF IC design houses, high-frequency packaging experts, and industrial end users.

Technical Approach

Fig. 2 shows our vision of a highly-integrated, miniaturized mm-wave sensor system in a low-cost package. As baseline package technology a plastic SMD-type package such as QFN or similar is targeted. The antennas become very small at mm-wavelengths and shall be integrated together with the IC into the plastic package. Various approaches will be investigated for antenna-in-package integration.

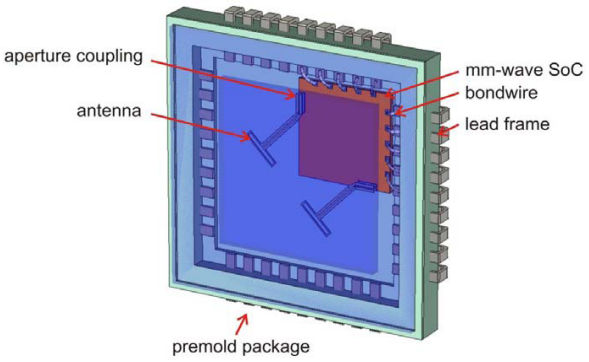

Fig. 2 Vision of a low-cost miniaturized mm-wave sensor system

A digitally controlled mm-wave radio with RADAR baseband processor will be implemented on a SiGe BiCMOS SoC. Here full digital control of analog/RF functions will be investigated as well as the coexistence of large digital circuitry with the mm-wave radio. As an option globally-asynchronous-locally-synchronous (GALS) processor will be developed to reduce interference of digital and analog/RF circuitry.

On-chip mm-wave self-test with digital read-out of test results will be developed. This alleviates greatly production test and will enable the use of conventional digital IC testers for mm-wave test

Key Issues

Technical challenges arise from a multitude of problems that occur from design at very high frequencies, very high integration levels and new integration concepts. Firstly a completely new integration concept on the package level is targeted and has to be proven to be valid for ultra-high frequency applications. Careful antenna-package co-design is needed. This requires precise 3D-modelling, electro-magnetic simulation and characterisation of RF IC interfaces, substrates and antennas. Different integration concepts, packaging and substrate materials have to be tested, compared, and benchmarked. Limits of production-level mounting and assembling and its effects on the RF performance have to be assessed wrt. performance and cost. Codesign of mm-wave IC and package is required, too.

Wrt. the mm-wave SoC and BIST design robust IC design concepts with full digital control of analog/RF functions and novel on-chip test schemes have to be found. Here again precise RF models are of utmost importance which requires advanced 3D modelling and electro-magnetic simulation. Furthermore the complexity of the SoC design approach requires a careful choice of the IC design flow and methodology such as analog-/RF-/digital mixed-signal codesign, simulation and appropriate concepts for mixed-signal full-chip-verification.

Expected Impact

The expected impact of the project is:

- New application ideas enabled by low-cost, miniaturized, mm-wave communication and sensor solutions
- A strengthened positioning of European industry as well as commercial exploitation of the developed high-frequency SiP approaches
- A strengthened positioning of European industry as well as commercial exploitation of mm-wave SoC design and mm-wave BIST know-how
- Cooperation between industry, academics and Member States
- Bossting of the commercial success of silicon mm-wave IC technologies and mm-wave SoCs